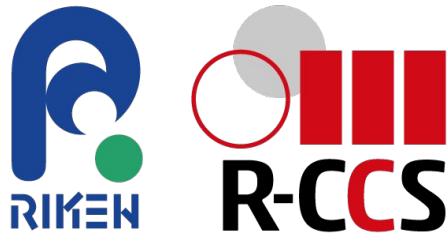


JLESC Research Collaboration: Monitoring the Arctic Climate



Data Assimilation Research Team,
RIKEN Center for Computational Science

T. Miyoshi, S. Kotsuki, K. Terasaki



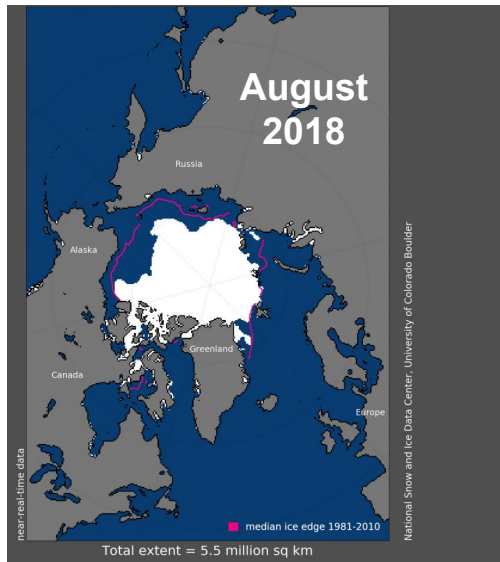
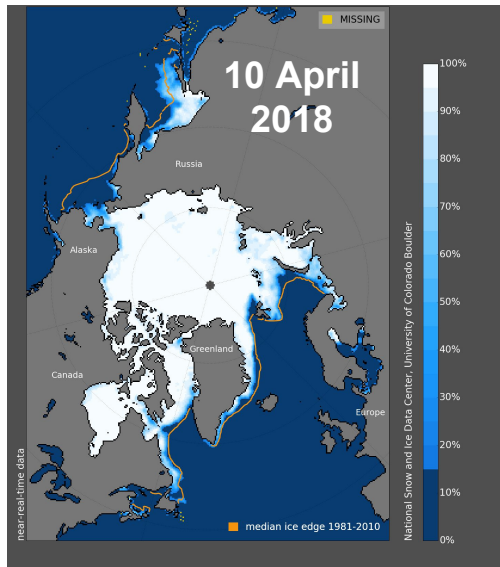
Earth Science Department

V. Guemas, K. Serradell, P. Ortega,
M. Castrillo, M. Acosta, J. Acosta,
P. Echevarria, E. Moreno-Chamarro

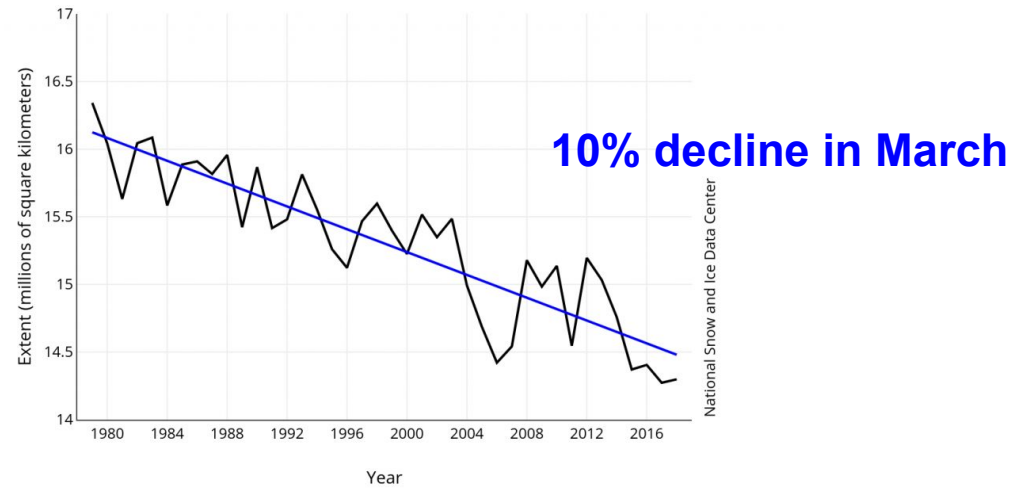
Context: A dramatic decline in Arctic sea ice...

Near-real time satellite observations from NSIDC

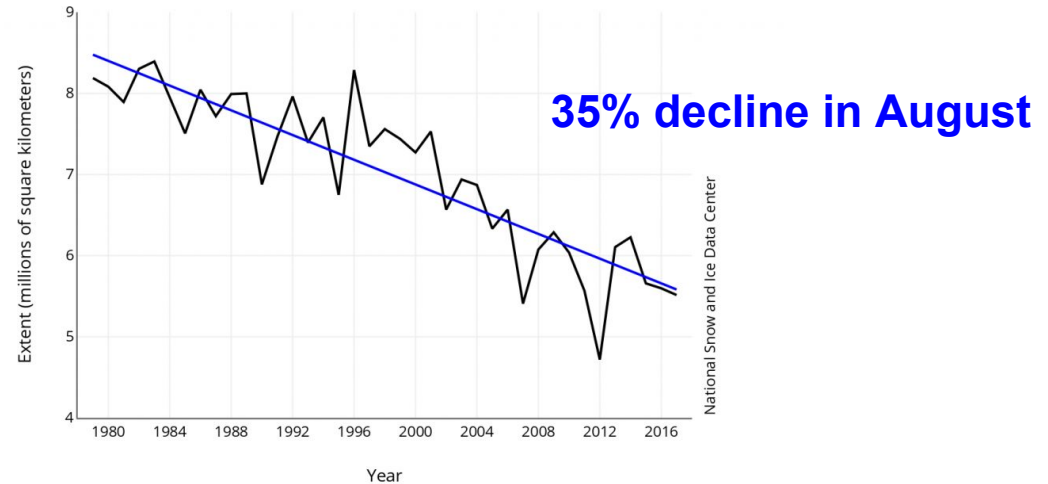
Sea Ice Concentration



March Arctic Sea Ice extent 1979-2018



August Arctic Sea Ice extent 1979-2017

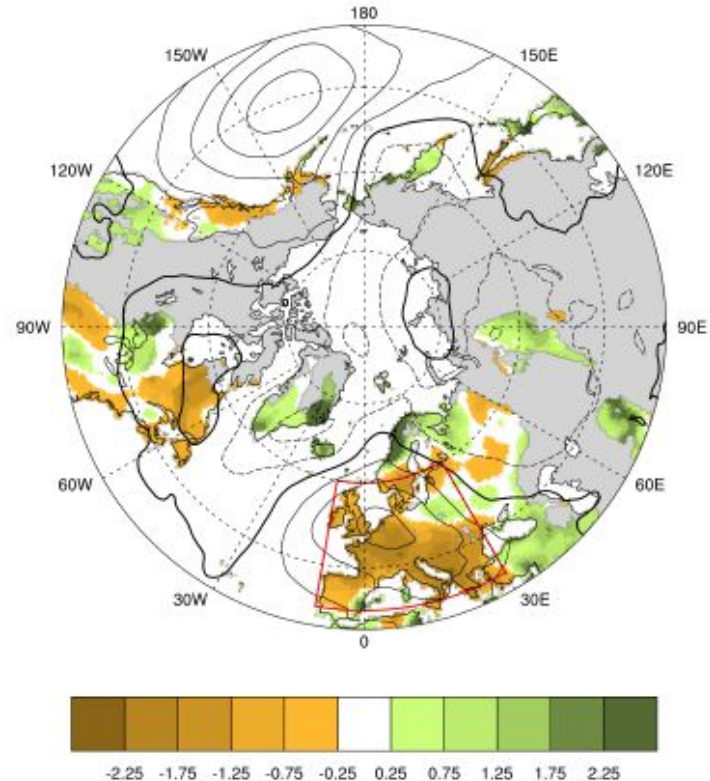
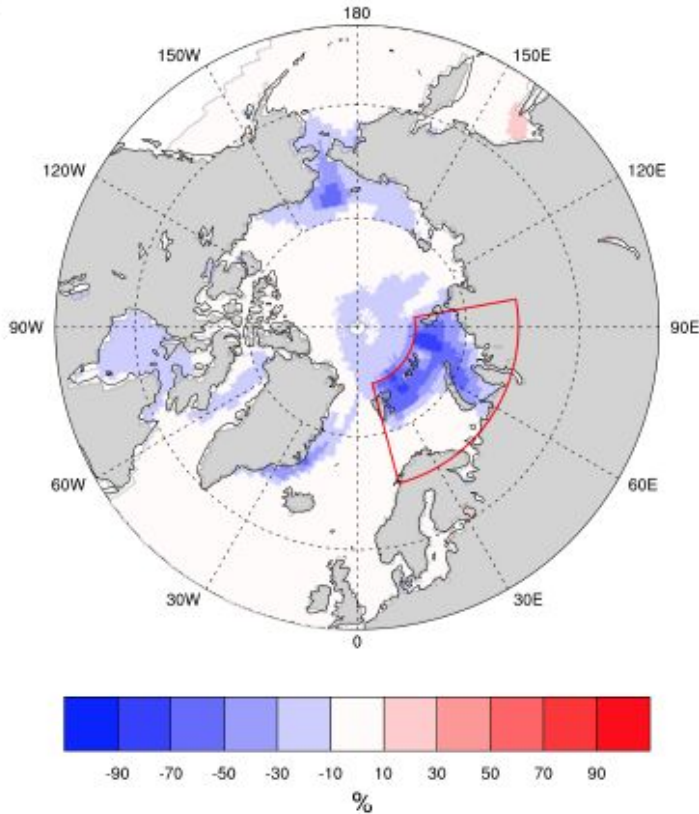


Context: ...with important climatic consequences

Acosta et al (Under review in *BAMS*)

Record low Sea Ice concentration in
Barents-Kara Seas (Nov-Dec 2016)

Record-low Precipitation in
Central Europe (Dec 2016)



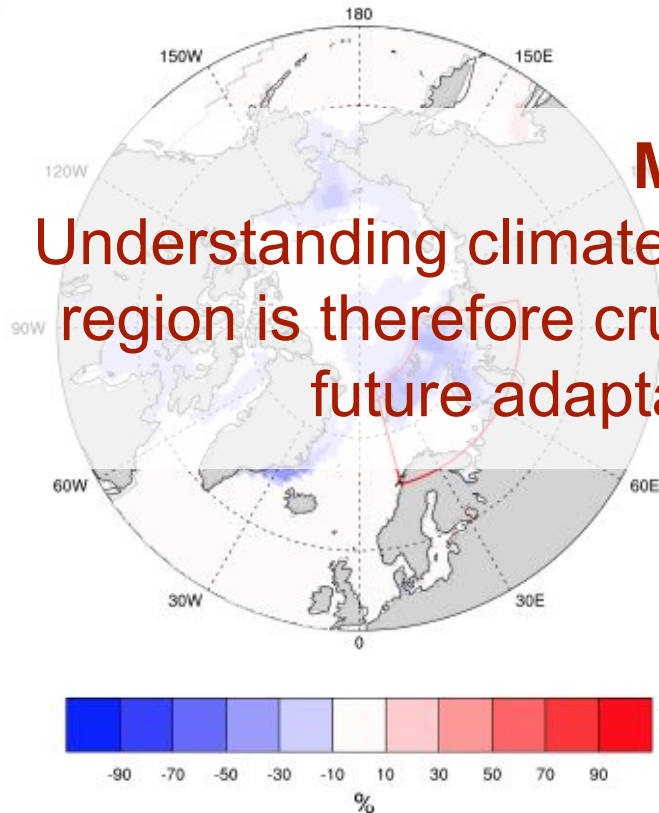
- Other impacts:**
- Frequency of cold NH midlatitude winters (**Cohen et al., 2012**)
 - Polar temperature amplification (**Manabe and Stouffer 1980**)
 - Commercial routes, ecotourism, resources extraction and industrial fishing

Context: ...with important climatic consequences

Acosta et al (Under review in *BAMS*)

Record low Sea Ice concentration in
Barents-Kara Seas (Nov-Dec 2016)

Record-low Precipitation in
Central Europe (Dec 2016)



MOTIVATION:

Understanding climate and sea-ice variability in the Arctic region is therefore crucial for **prediction purposes** and future adaptation/mitigation strategies

- Other impacts:**
- Frequency of cold NH midlatitude winters (**Cohen et al., 2012**)
 - Polar temperature amplification (**Manabe and Stouffer 1980**)
 - Commercial routes, ecotourism, resources extraction and industrial fishing

Cornerstones of Numerical Weather Prediction

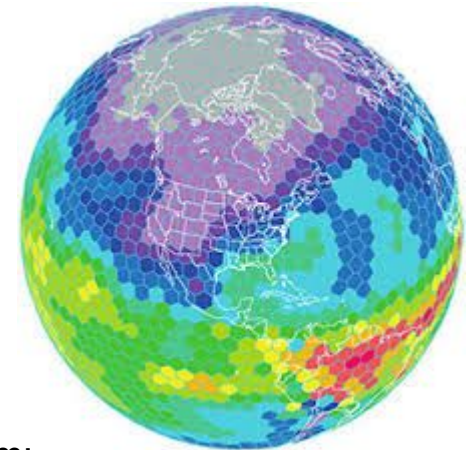
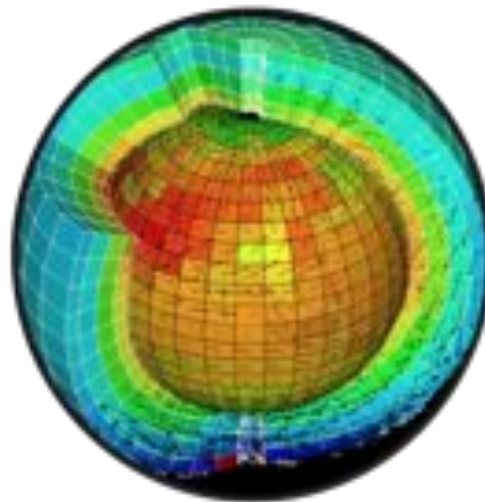
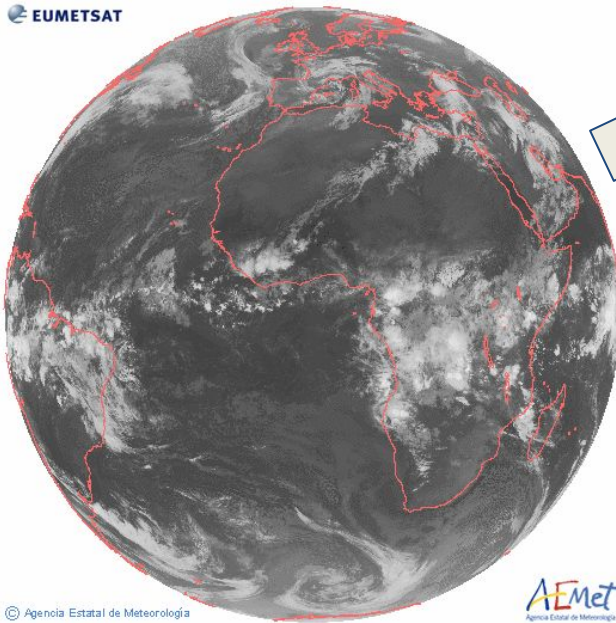
**For a given
atmospheric state**

**we can solve the
Governing equations**

$$\begin{aligned}\rho_o D_t \vec{v} + 2\Omega \times \rho_o \vec{v} + g\rho \hat{k} + \nabla p &= \vec{F} \\ \rho_o \nabla \cdot \vec{v} &= 0 \\ \partial_t \eta + \nabla \cdot (H + \eta) \vec{v}_h &= P - E \\ D_t \theta &= Q_o \\ D_t s &= Q_s \\ \rho &= \rho(s, \theta, p)\end{aligned}$$

**within a discretized
global climate model**

**To make a weather
prediction**



from:
<https://www.earthsystemcog.org/projects/esmf/>

Cornerstones of Numerical Weather Prediction

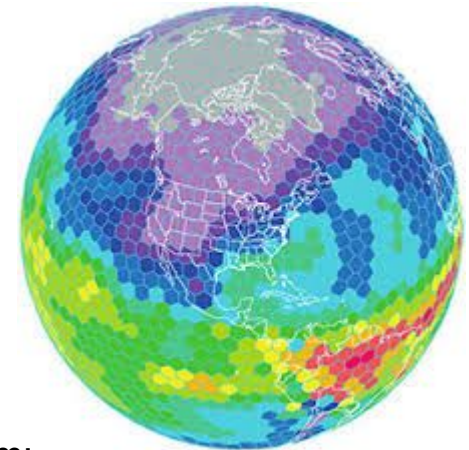
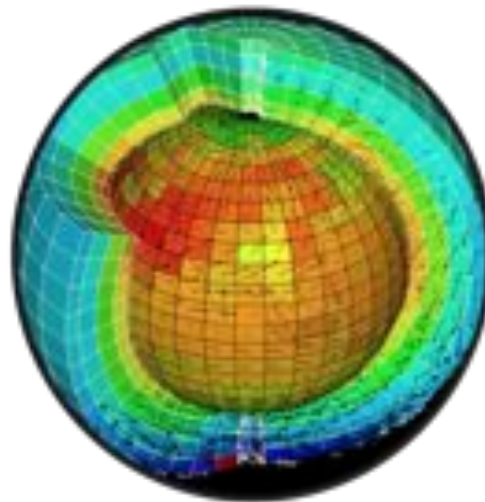
**For a given
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**To make a weather
prediction**

**within a discretized
global climate model**



from:
<https://www.earthsystemcog.org/projects/esmf/>

**Good predictions rely
on a good initialization
of the model with
observational data**

EUMETSAT

© Agencia Estatal de Meteorología

AEMet
Agencia Estatal de Meteorología

NICAM-LETKF: Global Atmospheric Data Assimilation System

S. Kotsuki, K. Terasaki, T. Miyoshi

Data Assimilation Research Team,
RIKEN Center for Computational Science, Japan



Overview on Data Assimilation

Observations

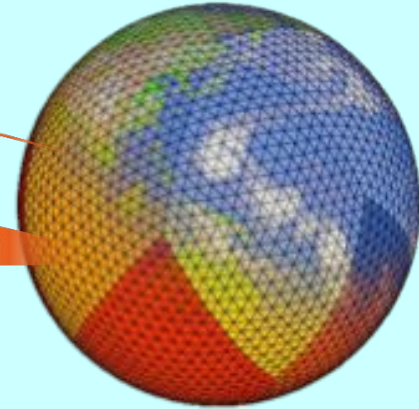


(JAXA)

LETKF

Data Assimilation

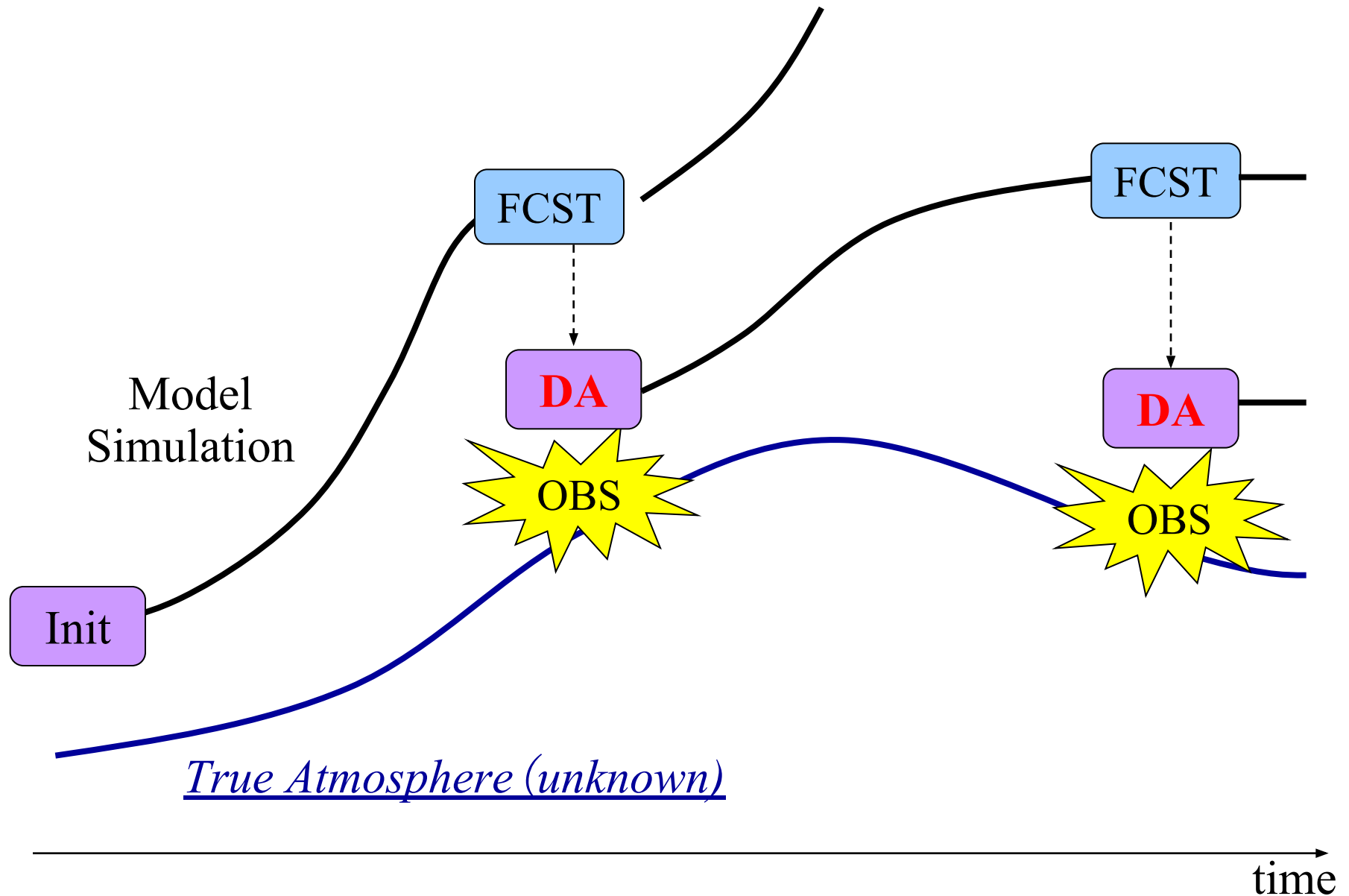
NICAM



Local Ensemble Transform Kalman Filter
(*Hunt et al. 2007*)

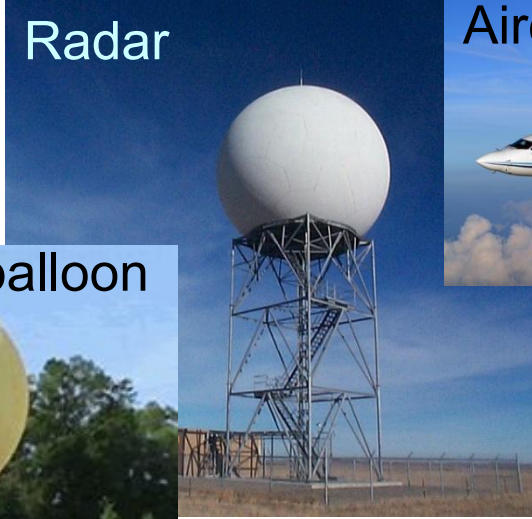
**Data assimilation combines
simulation and real world, and
brings synergy**

Numerical Weather Prediction



Global Observation System

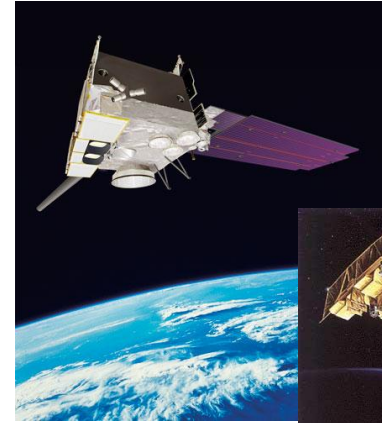
Radar



Aircraft



Satellite



Weather balloon



Ship



Buoy



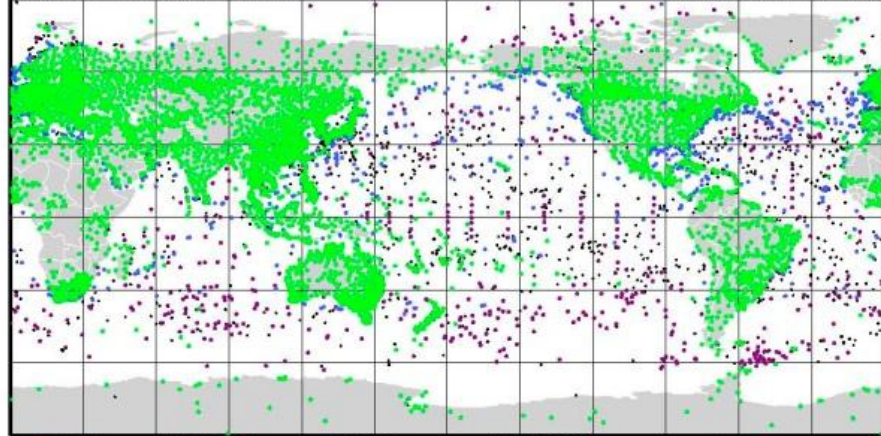
Surface station



Observation data (6-h period) (Courtesy of JMA)

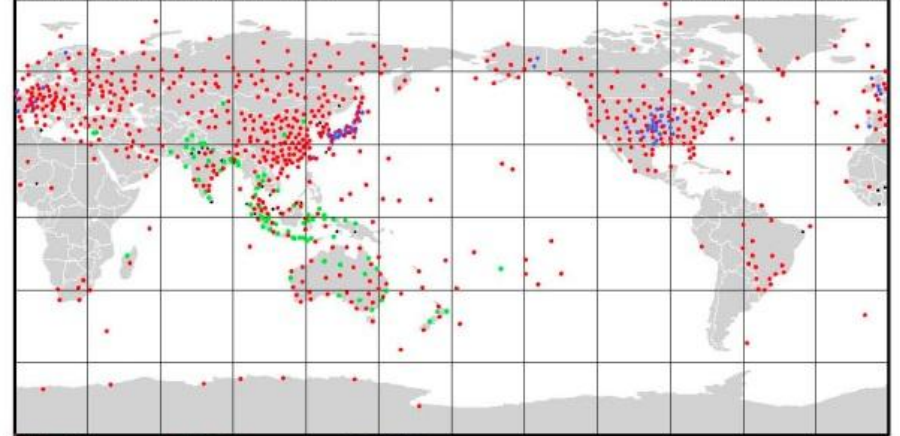
JMA GLOBAL ANALYSIS – DATA COVERAGE MAP (Da00ps): 2009/04/22 00:00(UTC)

CONVENTIONAL SURF 2009/04/22 00:00(UTC)



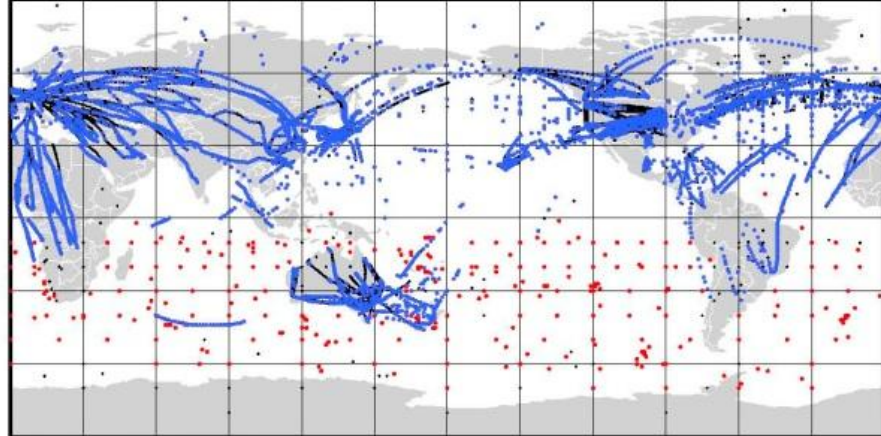
SYNOP: 12575 METAR: 3782 SHIP: 3011 DRIFTER: 7335 [●]NO_USE

CONVENTIONAL UPPER 2009/04/22 00:00(UTC)



TEMP: 636 PILOT: 311 WPROF: 1816 [●]NO_USE

CONVENTIONAL OTHERS 2009/04/22 00:00(UTC)



AVIATION: 28554 BOGUS: 345 [●]NO_USE

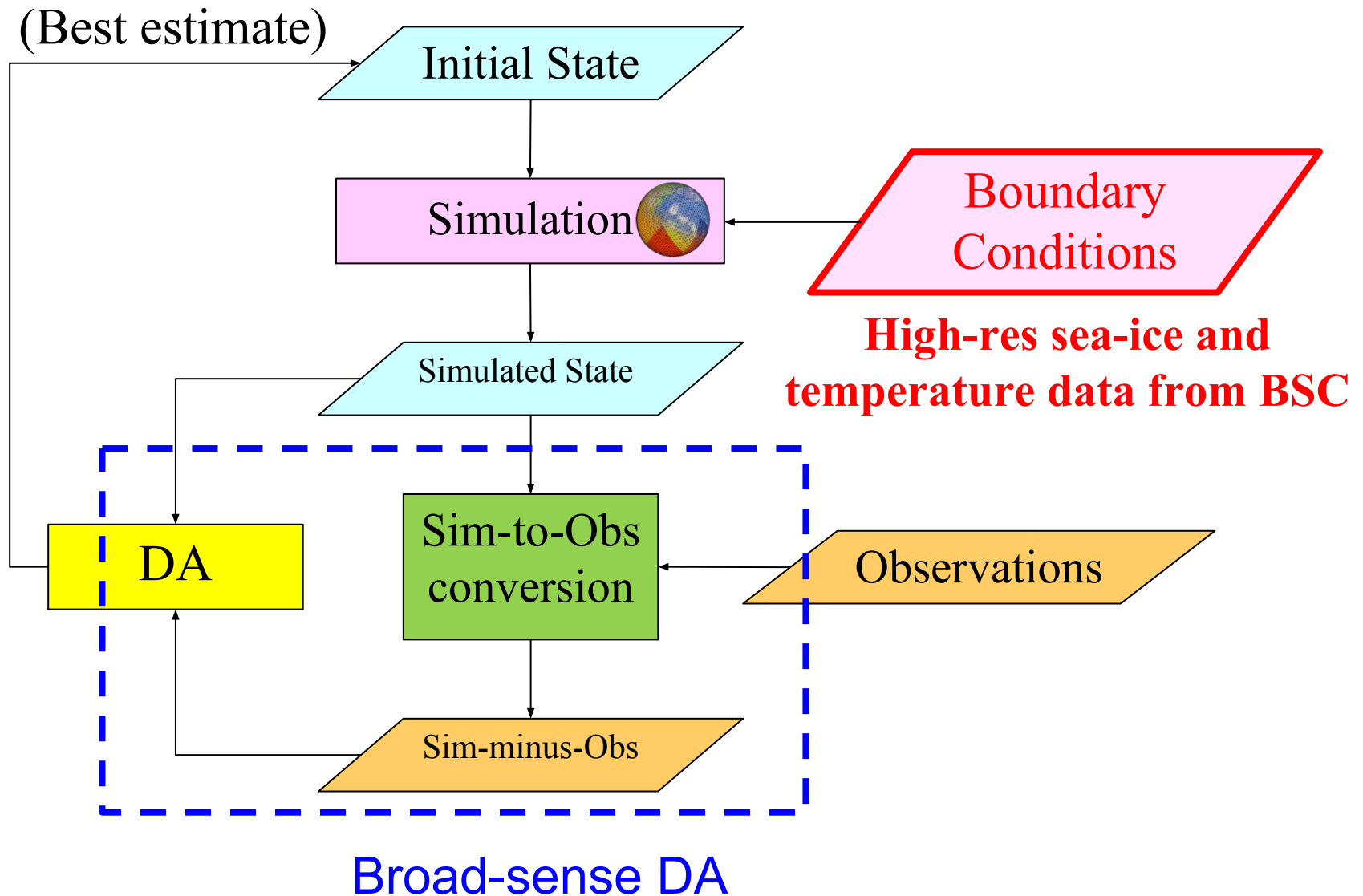
MW-SOUNDER(AMSU-A) 2009/04/22 00:00(UTC)



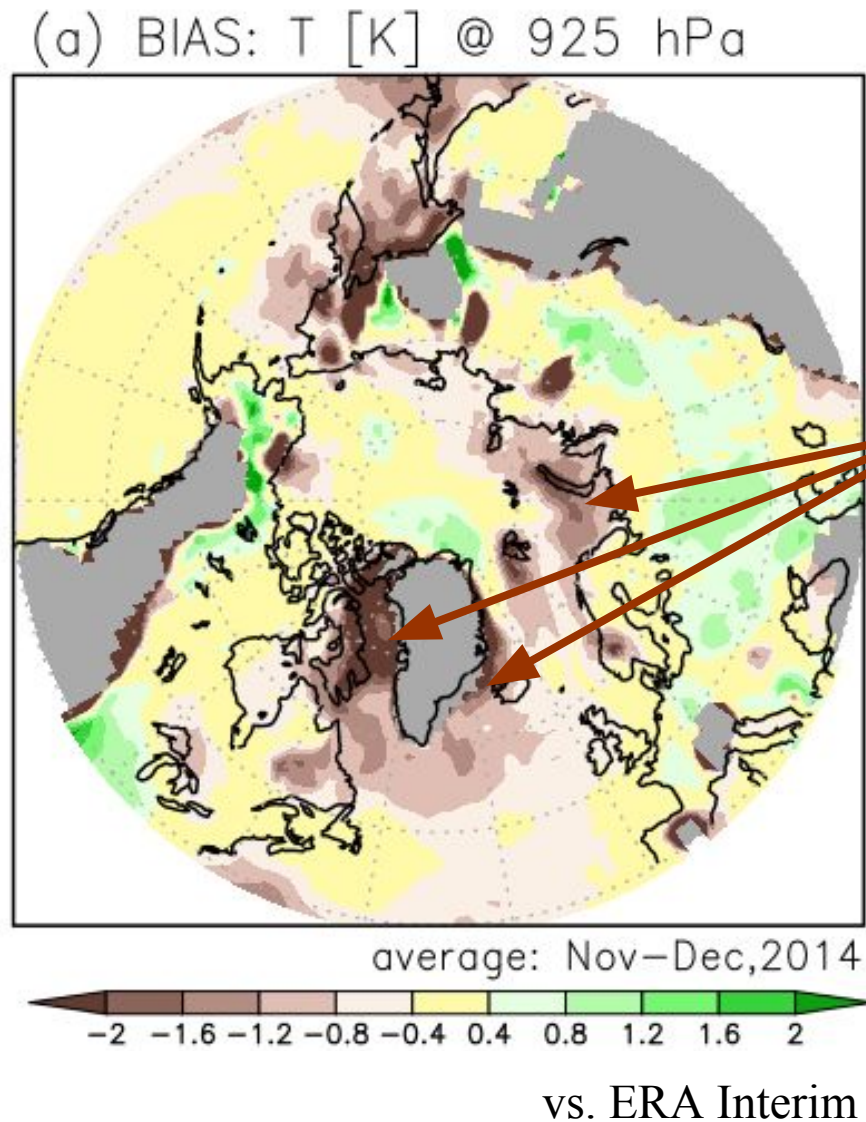
AMSU-A[●]: 18163
NOAA-15 NOAA-16 NOAA-18 METOP-2 [●]NO_USE

NWP has been pioneering “Big Data” science!

Workflow of Data Assimilation

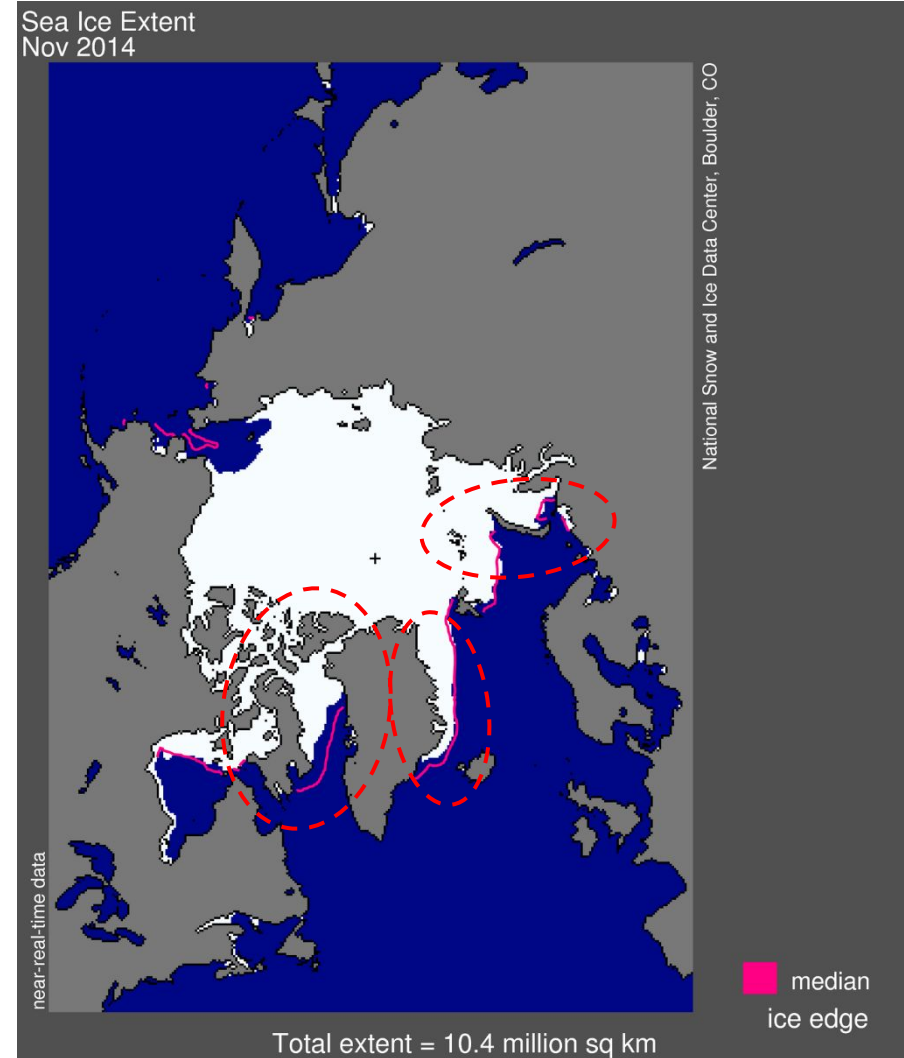
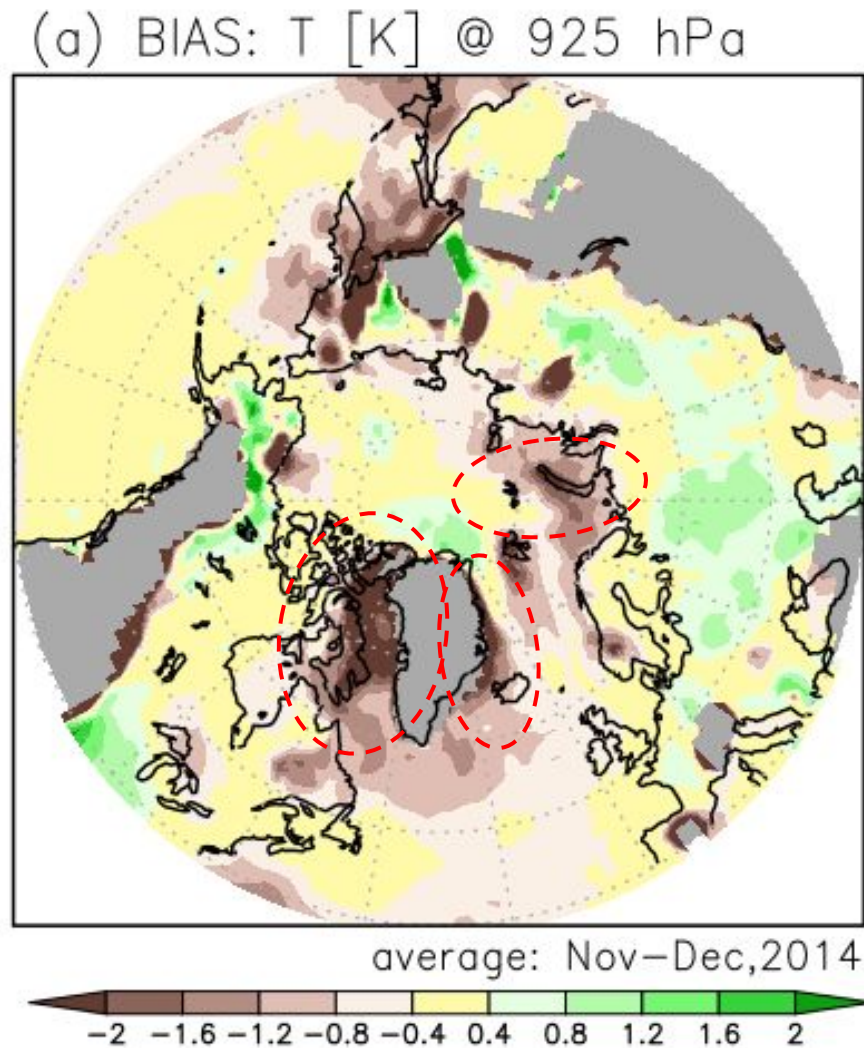


Caveat: Temperature Bias in NICAM-LETKF



Present NICAM-LETKF has
a cold BIAS
near the surface.

Caveat: Temperature Bias in NICAM-LETKF



NSIDC

Sea ice and temperature data may mitigate this problem!



**Barcelona
Supercomputing
Center**

Centro Nacional de Supercomputación



Arctic research activities at BSC:

From Sea Ice reconstructions to Seasonal-to-decadal (S2D) Prediction

V. Guemas, K.Serradell, P. Ortega, M. Castrillo, M. Acosta,
J. Acosta, P. Echevarria, E. Moreno-Chamarro

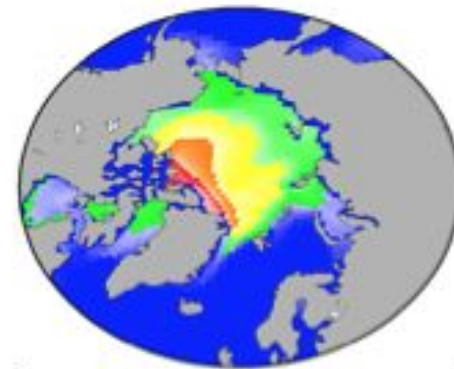
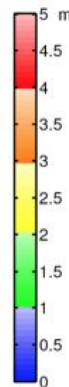
Arctic Research at BSC

- ICs for S2D Climate Predictions - **Sea Ice Reconstruction:**
 - Provides smoother initialization than observational products
 - Covers the period 1979-2015
 - Performed with coupled version of NEMO+LIM in Standard resolution ($1^\circ \times 1^\circ$)
 - Boundary conditions: Atmospheric forcing from DFS5.2
 - Assimilation of ESA and OSISAF (two european satellite products) Sea Ice concentrations using EnKF

Observed Sea Ice
Concentration Sep 2007



Reconstructed Sea Ice
Thickness Sep 2007

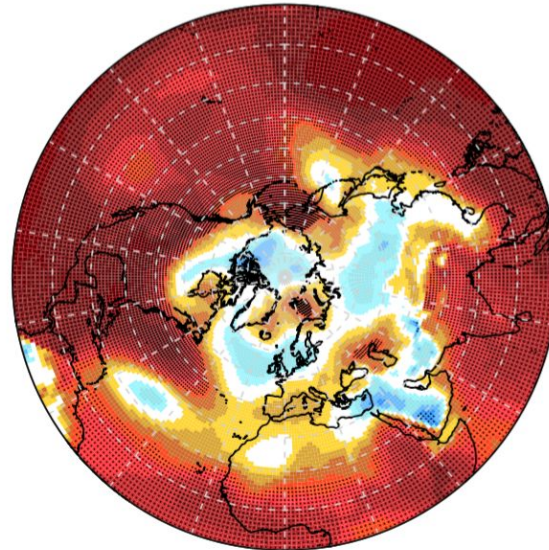
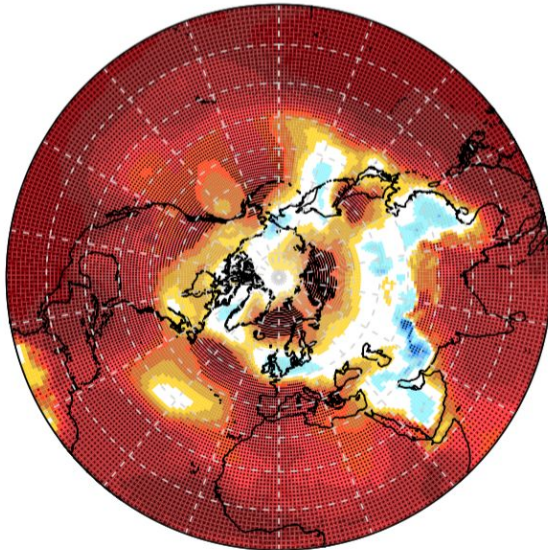


Impact of Sea Ice Initialization in Seasonal Climate Prediction skill

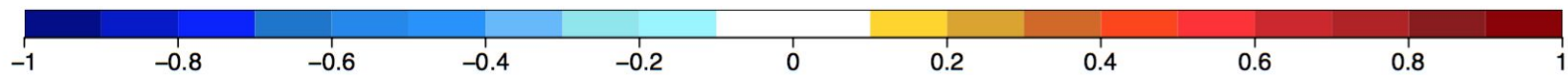
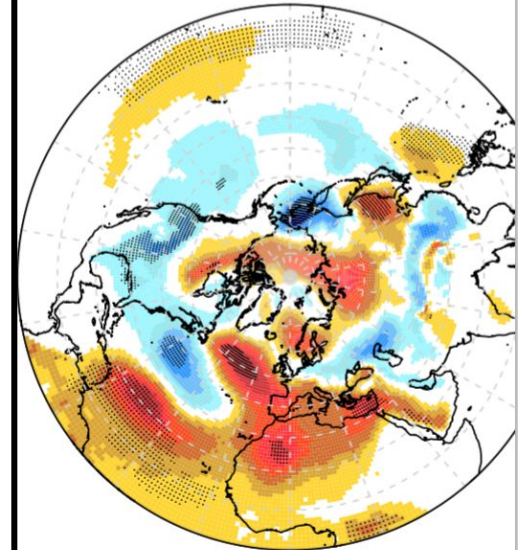
Skill in DJF SST

Sea Ice Assimilation
(EnKF)

Sea Ice Reconstruction
(Ocean nudging)



Difference in Skill



**More sophisticated initialization techniques for sea-ice
(EnKF) improve prediction skill in the mediterranean region**

Next steps of the Collaboration

- Porting the Ec-Earth Model to the K-Computer
- Developing and testing a new configuration to assimilate sea-ice with EnKF at high-resolution
- Producing a high-resolution sea ice reconstruction
- Incorporating the new HR reconstruction in the NICAM-LETKF Assimilation System
- Investigating the impact of these improved sea-ice initial conditions on the skill of NWP

Perspective

“*Big Data*” \leftrightarrow “*Big Simulation*”

For the next decade: Exa-scale computing

With the Post-K, we aim to run 1000-member
global NICAM-LETKF at 3.5-km resolution

→ Revolutionize Weather Prediction

in close collaboration with the FLAGSHIP 2020 project

